Overview of CHP Technologies, Applications and Benefits

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CHP Applications

- Electricity Generation
- Direct Drive
- Steam or Hot Water Production
- Direct Process Heating
- Process Heat Recovery
- Cooling and Refrigeration

CHP Technologies

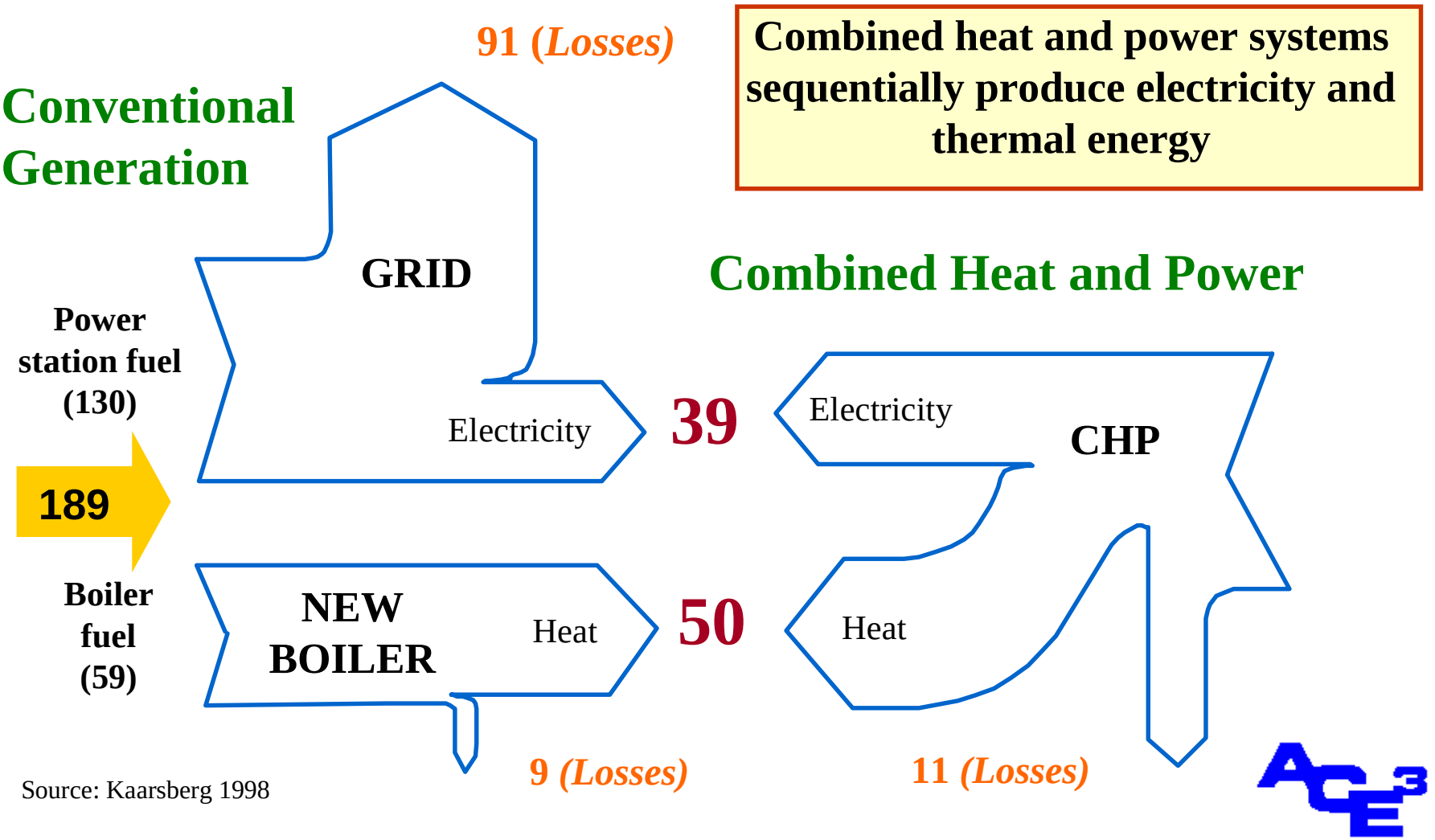
- Boiler
- Steam Turbines
- Combustion Turbines
- Reciprocating Engines
- Fuel Cells

CHP History

- CHP use has fallen and risen
- 100 years ago, most manufacturing plants used CHP
- As utilities' scale economies emerged and states' electric regulation increased, onsite generation decreased
- By the 1950's, utilities supplied more than two-thirds of all power to manufacturing
- During the late 1970's and 1980's, legislative incentives increased CHP
- Today, CHP continues to grow, but more slowly

What is CHP?

Combined heat and power systems sequentially produce electricity and thermal energy



Source: Kaarsberg 1998

Cogen or CHP

- Cogen (or Cogeneration) is a US term
- Europe has been using CHP
- National and international initiatives have created a need to connect the terms
- Europe is very far ahead of the US in Cogen

CHP Today in U.S.

- In 1996, 46 gigawatts (GW_e) of CHP
- >7 percent of the U.S. total.
- CHP is the largest *distributed* electricity technology
- Most at process industry sites with large steam loads.
- Some at large institutions

User Benefits of CHP

- Increased reliability
- Reduced energy costs
- Greater control/reduced risk
- Capacity for expansion and growth
- Opportunity for modernization

Public Benefits of CHP

- Increases energy efficiency
- Reduces emissions and pollution
- Promotes sustainable growth
- Helps address transmission and generation constraints
- Increases grid reliability
- Increases local tax base

CHP Market Segments

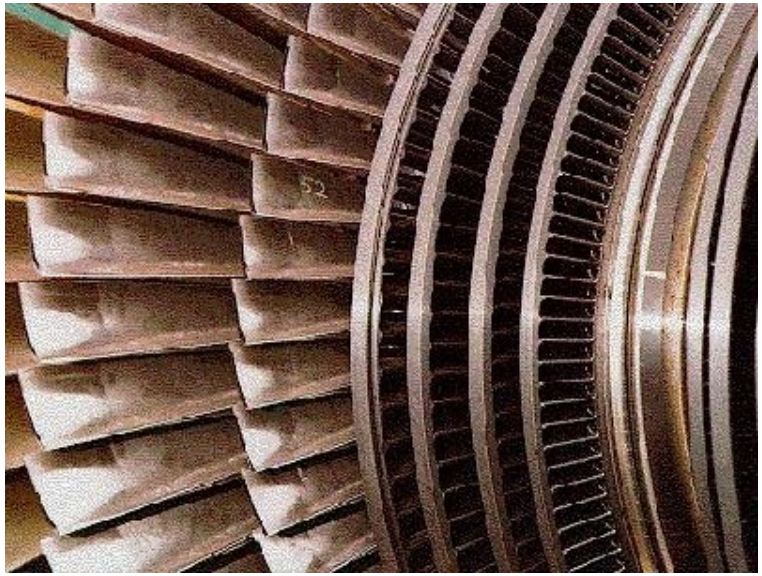
- Medium and Large Industrial (>40MW)
- Small and Medium Manufacturers (500kW-40MW)
- Medium and Large Commercial/Institutional Buildings (200kW-5MW)
- District Energy Systems (5-100MW)
- Small Commercial and Residential (self-powered) Buildings (30W-200kW)

HRSG's

- High temperature waste heat can make steam
  - using a ***heat recovery steam generator*** (HRSG)
  - auxiliary heaters in the HRSG can maintain heating
  - and steam can be easily transported throughout the plant

Steam Turbines

- Very established technology
- Fuel pressure does not need to equal steam pressure
- Slow startup (hours) so cannot be used as backup source - not ideal for peak shaving

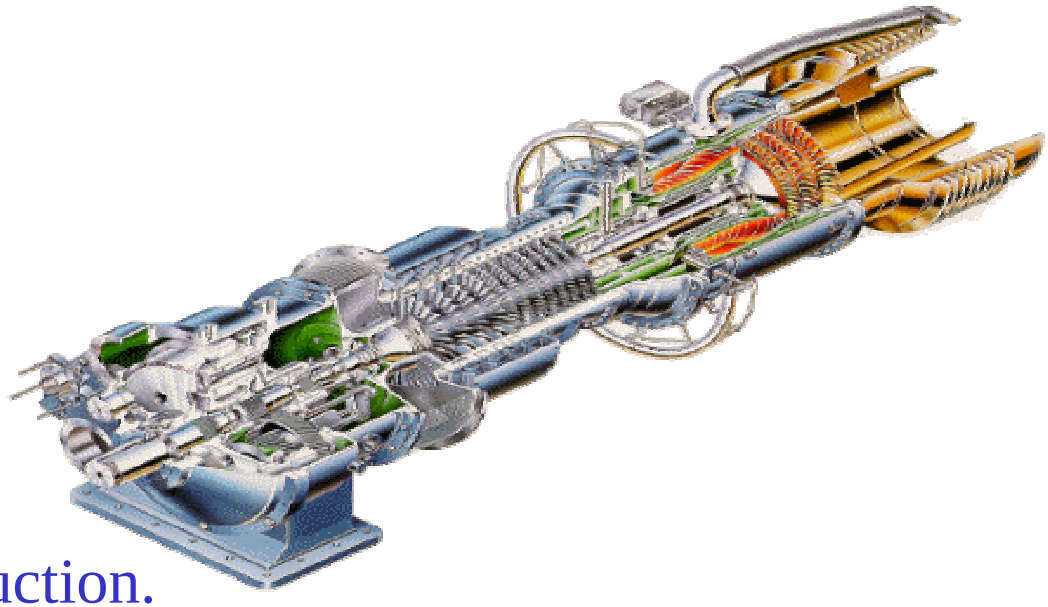


- Significant economy of scale (large units cost less per kW)
- Not clear if this technology is viable at <MW levels

Gas Turbines

- Have hotter exhaust than IC engines
  - needs to have cogen to cool exhaust or large and long exhaust pipes
- Higher pitch noise which can cause problems
- 50-90 second startup times (engines are faster) which is important when using as a backup
- Biggest current problem is reliable gas compressors
  - higher efficiency with higher pressure combustion

Gas Turbines



- If you need 5 MW or more, the technology is well established.
- For CHP, you normally don't need the highest electrical efficiency production.
- Aeroderivatives are current models derived from aircraft engines for power generation.
- Vendors say the turbines are multi-fuel capable which requires different setup for liquid and gas fuels.

Microturbines

Alternative to reciprocating engines

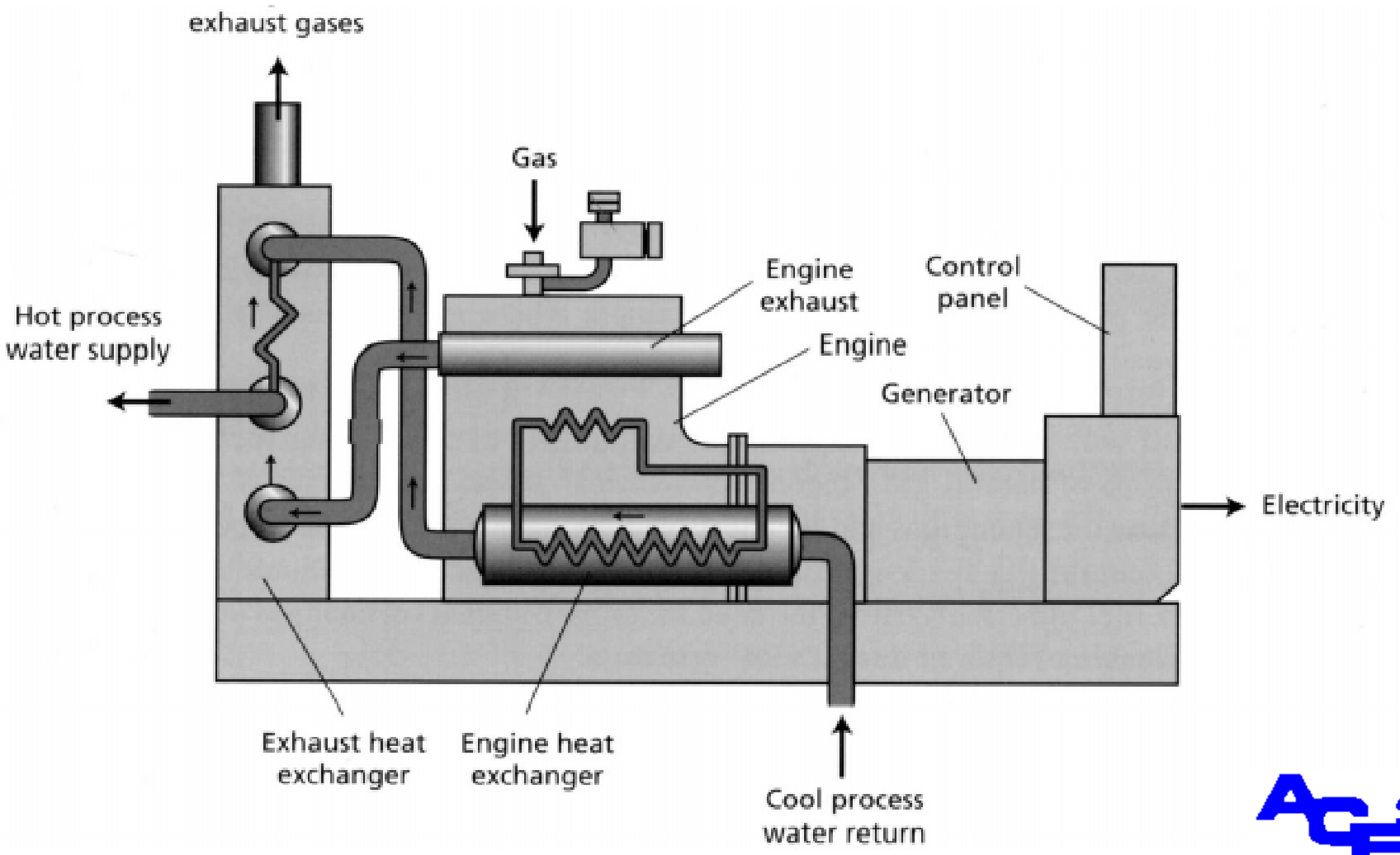
Allied Signal

parallon 75

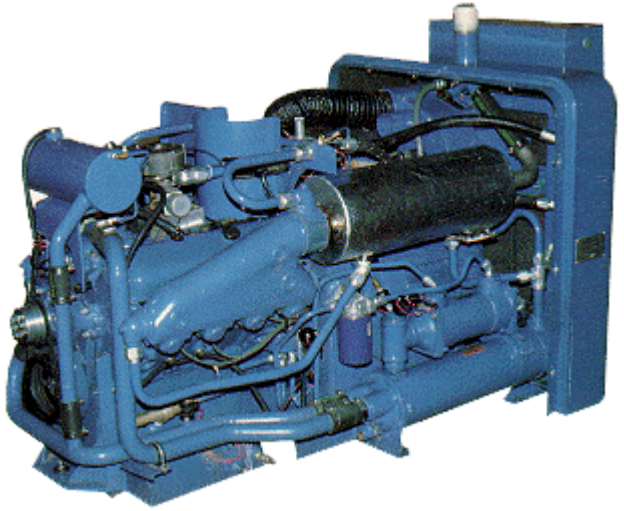
Capstone
MicroTurbine™
Model 330

POWERWORKS™ 70KW
Cogeneration Package
From *NREC/Ingersoll Rand*

Typical Engine Type CHP System



Diesels and Recips



- New diesels can go up to a 30% efficiency on small units (100 kW) and 35% on the largest units (megawatts)
- Large maintenance costs (lots of moving parts)
- Soot creates environmental problems
- Most diesels today use natural gas
- Because of duel fuel capability, they are available for base loading

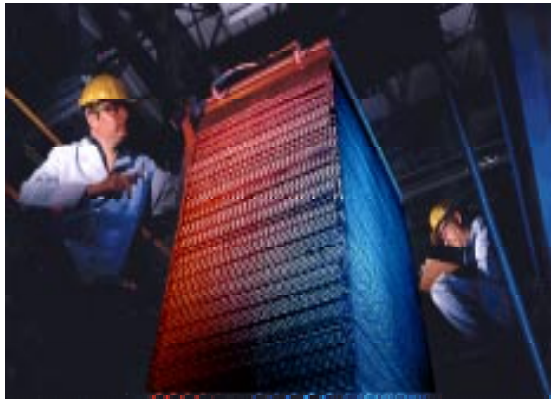
Fuel Cell CHP Systems for micro- to utility size markets

Proton exchange membrane fuel cell (PEMFC) <250 kW

Phosphoric acid fuel cell (PAFC) 200 kW - 10 MW

Solid Oxide electrolyte Fuel Cell (SOFC) 1-150+ MW

Molten Carbonate electrolyte Fuel Cell (MCFC) 1-100+ MW

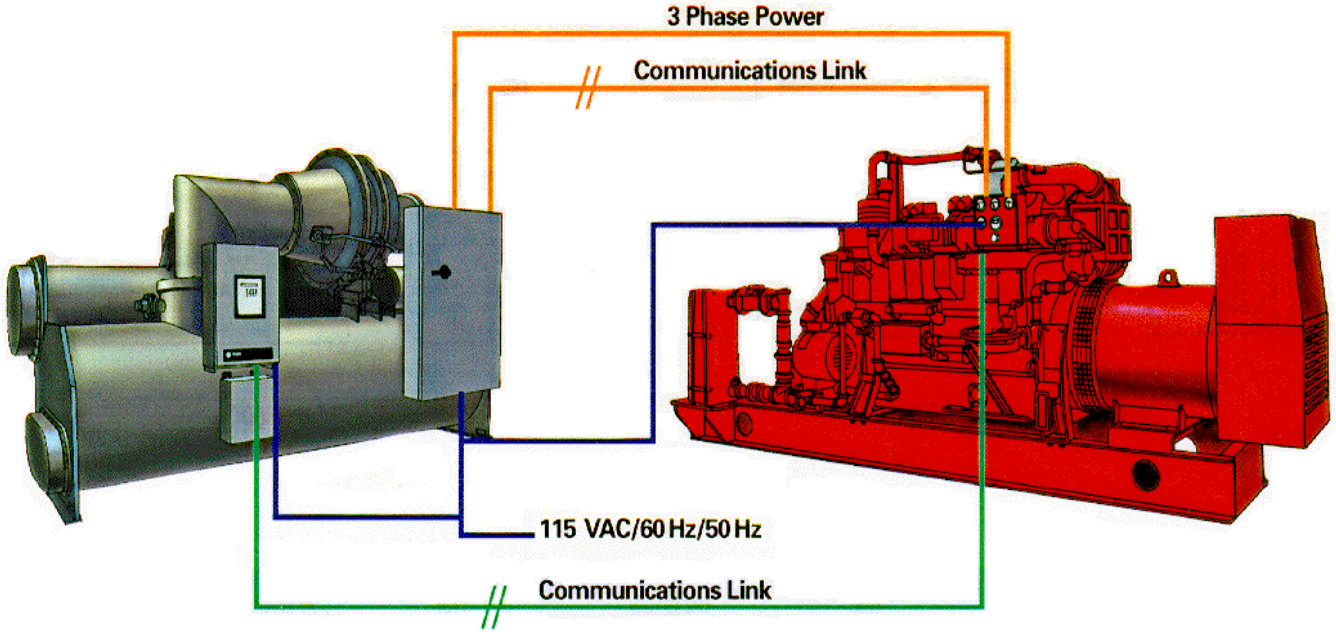


CHP is Not Always Cogeneration

This Dual Chiller is also CHP

HEAT--provided to
Absorption Chiller
from Engine for **Cooling**

Mechanical POWER
from **Engine-**Driven Chiller
provides direct Compression
Chilling



Related Technologies

- Absorption Cooling
- Desiccant Cooling
- Direct Drive Chillers
- Direct Drive Air Compressors
- Thermal Storage

Absorption Cooling

- Uses steam or hot water to produce chilled water
- Single Stage:
  - 100- 1600 Tons
  - Hot water (195-270 degrees F)
  - Low Pressure Steam (12 psi)
  - COP= .67
- Two Stage:
  - 300-1150 Tons
  - High Pressure Steam (115 psi)
  - COP- 1.20

Absorption Cooling

Single Stage Steam

Two Stage Steam

Desiccation

- Useful for both compressed air systems and space cooling
- Allows more outside air and reduces load on the cooling systems
- Great use for low grade waste heat!